ALASKA FISHERIES SCIENCE CENTER

EFFECTS OF FISHING GEAR ON SEAFLOOR HABITAT PROGRESS REPORT FOR FY 2003

edited by
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In 1996, the Alaska Fisheries Science Center (AFSC) initiated a number of seafloor habitat studies directed at investigating the effects of fishing on seafloor habitat. Each year a progress report for each of the projects is completed. A list of publications that have resulted from these projects is also included. Scientists primarily from the Auke Bay Laboratory (ABL) and the Resource Assessment and Conservation Engineering (RACE) Divisions of the AFSC have been conducting this work.

Exploration of coral and sponge habitat in the Aleutian Islands Principal Investigator - Robert Stone (Alaska Fisheries Science Center - ABL)

In July 2002 the manned submersible *DSV Delta* and scuba was used to explore coral and sponge habitat in the Central Aleutian Islands. Observations confirmed that coral and sponges are widely distributed in that region (corals and sponges were found at 30 of 31 submersible dive sites) and yielded the discovery of previously undocumented coral habitat consisting of high density "gardens" of corals, sponges, and other sessile invertebrates. Coral gardens were similar in structural complexity to tropical coral reefs with which they shared several important characteristics including a rigid framework, complex vertical relief, and high taxonomic diversity.

Following the initial exploratory efforts, Auke Bay Laboratory scientists, in collaboration with Alaska Department of Fish and Game and University of Alaska scientists, submitted two proposals for funding to expand this work. The first proposal to document deep-water (> 350 m) coral habitat, titled "Distribution of deep-sea corals and associated communities in the Aleutian Islands", was successfully funded by the National Underwater Research Program (NURP) for 2004 to use the remotely operated vehicle *Jason II*. The second, more comprehensive proposal, titled "Deep sea coral distribution and habitat in the Aleutian Archipelago" was successfully funded by the North Pacific Research Board (NPRB) and the first phases of that research began in June 2003 (see below: "Deep sea coral distribution and habitat in the Aleutian Archipelago").

In June and July 2003, the manned submersible *DSV Delta* was used to initiate the first phase of this project–shallow- water (<350 m) observations. This component of the study was funded by the Alaska Fisheries Science Center. Scientists visited 10 of 16 proposed sites and collected video of the seafloor on 22 strip transects. Corals and sponges were widely distributed over the 23 km of seafloor observed (found at 21 of 22 transects) and at densities varying from 0% on low-relief pebble substrate to 100% coverage in coral gardens. Disturbance to epifauna, likely anthropogenically induced, was observed at seven dive sites and may have been more evident in areas where fishing effort is reportedly high (based on NORPAC database). Sixty six coral specimens were collected for molecular and morphological taxonomic identification and studies on reproduction. Scientists will use the *DSV Delta* in 2004, with funding provided by NPRB, to complete observations at the six sites not visited in 2003.

Deep sea coral distribution and habitat in the Aleutian Archipelago Principal Investigators - Jonathan Heifetz (Alaska Fisheries Science Center - ABL), Jennifer Reynolds (University of Alaska Fairbanks), and Doug Woodby (Alaska Department of Fish and Game)

This project funded by the North Pacific Research Board (NPRB) seeks to provide the first detailed mapping of coral and sponge habitats for the Aleutian Islands, where species diversity appears to be unusually high and where incidental mortality of corals and sponges is a challenging problem in the area's fisheries that use bottom contact gear. The goal of this multidiciplinary study is to construct a statistical model to predict coral and sponge distribution as a function of measurable environmental characteristics, and if successful, this predictive model can be used to inform management decisions for protecting corals and sponges in areas lacking detailed mapping and dive-supported observations. Further, this work in collaboration with other projects, will provide estimates of the relative abundance of corals and sponges, their importance to commercially valuable fish and invertebrates, and the degree to which these living substrates have been disturbed, including disturbance by fishing gear.

This study focuses on the 500 km central section between Seguam Pass (174 W longitude) and Petrel Bank (180 W longitude). Field operations began in June 2003. The seafloor mapping operations were successfully conducted during a 22.5-day cruise on the R/V *Davidson* when multibeam bathymetry and backscatter surveys of 17 representative sites were completed. A total of seventeen sites were mapped throughout the central Aleutians with a combination of 100 kHz and 24 kHz multibeam systems. Wherever possible, the sites were mapped from 50m to 3000m water depth, using a 100 kHz multibeam sonar system down to ~400m water depth, and 24 kHz system at greater depth. The 100 kHz sonar produced excellent bathymetric and backscatter data (Figure 1). The 24 kHz bathymetry data were also excellent, though necessarily of lower resolution. Unfortunately, the 24 kHz backscatter data does not appear to be useful, as they are strongly dominated by slope effects and therefore repeat information

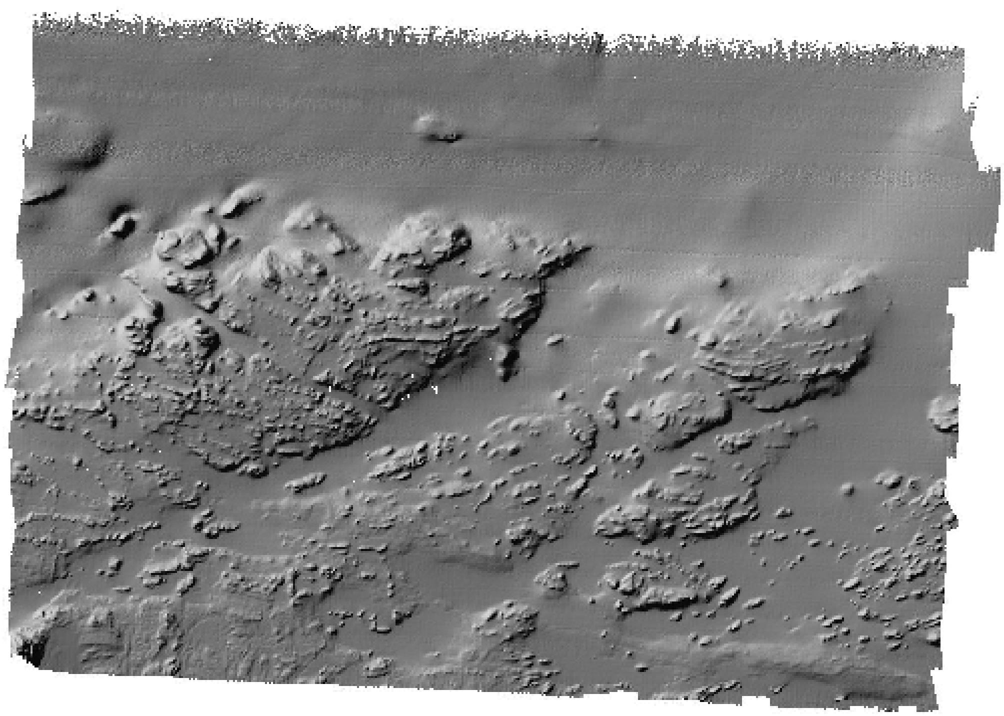

Figure 1. Example of a preliminary bathymetric map produced with the 100 kHz multibeam mapping system during the R/V *Davidson* cruise to the Aleutian Islands.

already contained in the bathymetry data

Juvenile rockfish habitat and energetics in the Aleutian Islands Principal Investigators Chris Rooper and Mark Zimmermann (Alaska Fisheries Science Center – RACE)

In May 2003, a pilot study was conducted to examine the feasibility of using echosounder data to delineate and map fish habitats in the eastern Aleutian Islands near the Islands of Four Mountains. The pilot study was carried out at three sites over two days prior to the beginning of the Gulf of Alaska trawl survey aboard the F/V Gladiator. At each site acoustic data from the vessel's echosounder were collected for analysis. These data are currently being processed with *QTC View* software that will generate data necessary to classify the area into habitat types. At each site a sediment sample was taken using a Shipek grab, and underwater video was collected using a drop camera to ground-truth the acoustic data. The preliminary results indicate one of the sites was heavily covered with epibenthic invertebrates (sponges and corals) over hard bottom. The other two sites are composed of sand and hard substrate, with the intermittent hard substrate supporting coral, sponges and other epibenthic organisms. If the features observed on the video and in the sediment collections are represented in the acoustic bottom classification, this method will prove to be a cost effective method of collecting habitat information using vessels of opportunity (NMFS contracted vessels) that conduct annual bottom trawl surveys throughout Alaskan waters.

Studies from wide ranging areas have indicated that many commercially important species are associated with specific habitats. Rockfish of many species are often found in association with structured habitats (rock piles, coral patches, etc.) of some kind. Some effects of fishing on epibenthic invertebrates have been observed, however it is unclear what the consequences of the fishing activity on fish species associated with these sheltering invertebrates may be. A second purpose of the 2003 pilot study was to initiate techniques to identify links between habitat forming organisms (primarily sponges and corals), rockfish density, and rockfish condition. Since the energetic content of fish can be used as an indication of fish condition, the energetic content of fish collected from various habitats should reflect the relative value of the habitat to the fish. For example, poor quality habitat should be reflected by lower energetic content of individuals occupying the suboptimal habitat. Trawl collections at the three study sites were dominated by rockfish (Pacific ocean Perch and northern rockfish), Atka mackerel, and Pacific cod, as well as substantial sponge and coral. Juvenile rockfish were collected and frozen for laboratory analysis of energetic and stomach content (both at the three study sites and throughout the Gulf of Alaska during the 2003 survey). Zooplankton samples were also collected at each trawl location. Energetic content and zooplankton abundance will be compared among sites and treatments to determine the relative benefit to rockfish growth and condition of one site over another. This will allow us to evaluate the linkage between the function of structured habitats and the fish that are associated with these complex habitats. In 2004 we hope to extend this study to further evaluate acoustic mapping techniques, and explore the relationships between fish and structured habitat in the Aleutians thus supporting interpretation of gear impact studies.

Red king crab and bottom trawl interactions in Bristol Bay Principal Investigators - C. Braxton Dew and Robert A. McConnaughey (Alaska Fisheries Science Center - RACE)

The 1976 Magnuson Act effectively eliminated the Bristol Bay no-trawl zone known as the Pot

Sanctuary. Implemented by the Japanese in 1959, the boundaries of the Pot-Sanctuary refuge closely matched the well-defined distribution of the red king crab population's mature-female brood stock, thus affording a measure of protection to the reproductive potential of the stock. In 1980, the point at which the commercial harvest of Bristol Bay legal-male red king crab reached an all-time high after a decade-long increase, domestic bottom trawling in the brood-stock sanctuary began in earnest with the advent of a U.S.-Soviet, joint-venture, yellowfin sole fishery. As the number of unmonitored domestic trawls in the brood-stock area increased rapidly after 1979 and anecdotal reports of "red bags" (trawl cod-ends filled with red king crab) began to circulate, the proportion of males in the mature population (0.25 in 1981 and 0.16 in 1982) jumped to 0.54 in 1985 and 0.65 in 1986. It is unlikely that normal demographics caused this sudden reversal in sex ratio. Our hypothesis is that alternating, sex-specific sources of fishing mortality were at work. Initially there were ten years (1970-1980) of increasing, male-only exploitation, followed by a drastic reduction in the male harvest after 1980 (to zero in 1983). Then, beginning around 1980, there was an increase in bottom trawling among the highly aggregated, sexually mature female brood stock residing within the Unimak area, known to be the most productive spawning ground for Bristol Bay red king crab. There has been considerable discussion about possible natural causes (e.g., meteorological regime shifts, epizootic diseases) of the abrupt collapse of the Bristol Bay red king crab population in the early 1980s. This project focuses on the association between the overharvest of male crab in the directed fishery, the onset of large-scale commercial trawling within the population's primary reproductive refuge, and the population's collapse.

Distribution of flathead sole by habitat in the Bering Sea Principal Investigators Chris Rooper and Mark Zimmermann (Alaska Fisheries Science Center – RACE Division)

During 2003, biotic and abiotic variables were analyzed to identify preferred habitat for flathead sole in the Bering Sea. A model was constructed based on data from three Bering Sea bottom trawl surveys and then tested on data from two different years. Habitat variables were chosen based on their presumed importance for growth and survival, and included sediment type, temperature, depth, prey biomass, and invertebrate cover. Bottom temperature and depth were available for each trawl haul. Additional data was used to calculate the ratio of mud to sand at each site. Sheltering organisms included sea anemones, soft and hard corals, surface bivalves, empty bivalve shells, ascidians, gastropods, sponge, bryozoans and sea pens. The total weight of important prey items such as decapods (including shrimp and pagurid crabs), juvenile walleye pollock, and ophiurids was summed for each tow. Three models were used to describe the relationships between flathead sole catch (ln CPUE) and each of the five habitat variables. The most complex model was a three-parameter model representing the response of CPUE as a dome shaped function of the habitat variable. A second model describes CPUE as a density dependent function of the habitat variable. The simplest model predicted a linear relationship between flathead sole density and the habitat variable. In addition a functional response model was used to describe the relationship of flathead sole to their prey. The initial (full) model for analysis estimated 14 parameters. Models were reduced by sequentially removing one parameter for each variable, and then the models were compared using the Akaike Information Criterion (AIC) for non-nested models, and the process was repeated until reduction in the number of parameters resulted in no gain in AIC score. The correlation between the observed and predicted values was used to determine the percentage of variance in the data set explained by the model. Once a final model was determined for 1998-2000, the model was tested on survey data from 2001 and 2002.

The best model of flathead sole habitat use included four habitat variables; depth, temperature, invertebrate cover and mud-sand ratio. Predicted values from the 7-parameter model were highly correlated (r = 0.78) with the original observations. Flathead sole abundance increased sharply from 0 to 150 m and then decreased at greater depths. Flathead sole CPUE increased in proportion to the amount of available cover, and CPUE increased quickly from –2 to 3 ^{0}C and then leveled out at temperatures higher than 5 ^{0}C. Flathead sole had an inverse proportional relationship with the mud-sand ratio. Including the prey abundance variable in the model did not provide any advantage in predicting flathead sole CPUE according to the AIC. This was the only variable dropped from the original five variable model. The fit of the model to the test data (2001-2002) was almost as good as the original fit on the 1998-2000 data, as the predicted values were also highly correlated (r = 0.76) to the observations. The model had difficulty predicting the largest observations of flathead sole catch, and residual plots of the model fits from each year suggest the model tends to under-predict observations in the southern region of the Bering Sea shelf, while over-predicting the observations in the northern shelf in 1998-2000. This suggests an important habitat variable is not included in the model and the matter will be investigated further.

A model for evaluating fishery impacts on habitat Principal investigators - Jeffrey Fujioka and Craig Rose (Alaska Fisheries Science Center - ABL and RACE)

A mathematical model to evaluate the effects of fishing on benthic habitat was developed. The model has been applied within the framework of the both the Programatic and Essential Fish Habitat (EFH) supplemental environmental impact statements prepared by Center scientists. The model is comprised of equations that incorporate the basic factors determining impacts of fishing on habitat. Given values, either estimated or assumed, of 1) fishing intensity, f (= absolute effort in area swept per year ÷ area size), 2) sensitivity of habitat to fishing effort, q_H, and 3) habitat recovery rate, ρ, the model predicts a value of equilibrium (i.e., long term) habitat level, H_{eq}, as a proportion of the unfished level, H_0.

$$H_{eq} = H_0 \cdot \rho S/(I + \rho S) \qquad \text{Where } H_0 = \text{unfished habitat level, } I = f\, q_H \text{, and } S = e^{-I}.$$

Habitat impact or effect level, E, for the given effort, sensitivity, and recovery rates, would be 1- H_{eq}. Letting H_0 = 1.0, then

$$E = I/(I + \rho S)$$

Habitat is defined as any feature of the seafloor that could be impacted by fishing gear. Initially, application of the this model focused on the impact to biostructure habitat feature where biostructure is living habitat provided by organisms such as corals, tunicates, and sponges.

The habitat sensitivity rate, q_h, is the proportion of habitat in the path of the fishing gear that is impacted by one pass of the gear. Vulnerability of the a particular habitat feature varies greatly depending on their physical characteristics and the characteristics of the fishing gear. The vulnerability may be difficult to determine. Certain features of the gear may make the gear more damaging to one type of organism than to another type.

Recovery rate, ρ, reflects the rate of change of impacted habitat back to unimpacted habitat, H_0. In the absence of further impacts, impacted habitat would decrease exponentially until all habitat was in H_0 the condition. The recovery time, R, can be thought of as the average amount of time the impacted habitat stays in the impacted state, which would equal 1/ρ (in the absence of further impacts). The recovery rate includes any recruitment required to initiate recovery and the growth necessary to reach a size that is necessary to provide habitat function.

Fishing intensity is the absolute effort in area swept per year ÷ area size. To keep a geographic perspective application of the model used fishing effort estimated for each 5x5 km block within the EEZ. Fishing intensity of a block is the fishing effort per year measured in area swept as a proportion of area of the block. For the given values of sensitivity q_h, recovery rate ρ, and bottom fishing intensity *f* estimated for each 5x5 km block, habitat impact, $E_i = I_i/(I_i+\rho S_i)$, can be calculated for the 5x5 km block represented by the *I* parameter. Larger values of *E* equate with more impacts. Results for a region can be presented in a single value as a mean impact, frequency distribution of impacts for each block, and the geographic distribution of the impacts.

Ecological value of physical habitat structure for juvenile flatfishes Principal Investigator – Allan W. Stoner (Fisheries Behavioral Ecology Program, RACE Division, Alaska Fisheries Science Center)

Distributions of flatfishes are ordinarily associated with depth, temperature, and sediment type. In fact, new experiments conducted at the Newport Laboratory show that juveniles of both northern rock sole and Pacific halibut have strong preferences for sediments with specific grain sizes which are related to the fish's burial capabilities. These preferences are strongest in the smallest age-0 fish and decrease with fish size. However, both experimental and descriptive studies conducted in the Fisheries Behavioral Ecology Program also show that some juvenile flatfishes have strong preferences for habitats with physical structure created by large epibenthic invertebrates, biogenic structures in the sediment, and sand waves. Fine-meshed beam trawl collections made near Kodiak revealed that densities of age-0 rock sole and Pacific halibut were correlated with physical structures provided by empty shells and sedentary invertebrates collected as bycatch in the tows. Additional laboratory experiments conducted in the Newport Laboratory show that age-0, age-1, and age-2 Pacific halibut all choose habitat with structure over bare sand habitat. Strength of the preference decreases with fish size, and depends upon both feeding history and light level.

Reductions in habitat heterogeneity may have important ecological consequences for juvenile flatfishes. Complex habitats with sponges, bryozoans, shells and other physical structures can reduce mortality rates on juvenile flatfishes compared with habitats not containing physical structure. Predation rates on age-0 rock sole and age-0 Pacific halibut by age-2+ halibut were tested in large laboratory mesocosms with and without physical structure (sand plus sponges versus smooth bare sand). Predators consumed more flatfish prey in sand than in habitat with sponges, and they consumed more age-0 halibut than rock sole. Predator-prey encounter rates were decreased in the sponge habitat as predator search was impeded. Predators paused more frequently and swam more slowly to maneuver through the complex habitat. Structures also hindered the pursuit of prey. These experiments support an accumulating body of evidence that emergent structure, in otherwise low-relief benthic habitats, may play an important role in the ecology of some juvenile fishes. Removal of emergent structure by towed fishing gear and other anthropogenic or natural disturbances may influence patterns of distribution for juvenile halibut as fish redistribute to less preferred habitat, and may decrease survival rates through increased losses to predation.

During 2003, field studies were expanded with a grant from the North Pacific Research Board to include a descriptive analysis of flatfish/habitat associations in flatfish nursery grounds near Kodiak Island using a new towed camera system that is integrated with navigation. Approximately 50 hours of videotape were recorded and analysis is currently underway. Also, a field experiment was designed to examine the role of habitat structure by enhancing large plots of bare sand with bivalve shells. The plots were then surveyed with the camera sled at several intervals over the following month. The experimental results are currently being analyzed, but it is already clear that certain flatfishes were attracted to the enhanced habitat. Similar field studies will continue in 2004.

Mapping of habitat features of major fishing grounds Principal investigators Jonathan Heifetz and Dean Courtney (Alaska Fisheries Science Center - ABL)

Very few areas of the continental shelf and slope where major fisheries occur have been adequately described using geophysical and biological data. Any regulatory measures adopted to minimize impacts without the information of whether or where vulnerable habitat is at risk, may be ineffective or unnecessarily restrictive. Habitat mapping along with direct in-situ observations is a way of obtaining such information. The objective of this study is to map limited areas of the Alaska EEZ for habitat characterization using state-of-the-art technology. In 2001 and 2002 approximately 1,600 km^2 of seafloor was mapped using a high-resolution multibeam echosounder that includes coregistered backscatter data. This mapping consisted of 500 km^2 off Yakutat, 900 km^2 on Portlock Bank northeast of Kodiak, and 200 km^2 off Cape Omaney, Baranoff Island. Survey depths ranged from about 100 m to 750 m. During 2003 we mapped areas in the central Aleutian Islands and in the vicinity of Albatross Bank southwest of Kodiak Island in the Gulf of Alaska.

Analysis of the multibeam and backscatter data for Portlock Bank indicated at least a dozen macro- or meso-habitats. The megahabitats are the result of past glaciation and are presently being reworked into moderate (cm-m) relief features. Submarine gullies notch the upper slope and provide steep relief with alternating mud-covered and consolidated sediment exposures. The Cape Omaney site ranged in depth from approximately 50 m - 300 m (Figure 2). This site is characterized as an irregular seabed with mixed sediments (mostly sand and gravel) and high-relief rocky outcrops and pinnacles. The habitat at the Cape Omaney site is the result of past glaciation and plate tectonics highlighted by the presence of an uplifted fault zone. The Yakutat site is characterized as as a formerly glaciated area of irregular seabed with mixed sediments (mostly sand, mud, and gravel) and high-relief areas consisting mostly of boulders.

At the Cape Omaney and Portlock Bank sites the mapping was complemented by submersible *Delta* dives. The uplifted fault zone (shatter ridge) was the focus of the *Delta* dives at the Cape Omaney site. The ridge is comprised of a series of pinnacles. The substrate is primarily bedrock and large boulders. The epifaunal community is rich and diverse, much more so than the surrounding low-relief habitat. The largest epifauna were gorgonian red tree coral colonies and several species of sponges. Numerous species of fish, including several species of rockfish, were abundant. Redbanded rockfish and shortraker/rougheye rockfish were often associated with gorgonian coral colonies and at least one species of sponge. Also of interest was the presence of a pod of several hundred juvenile golden king crab on acorn barnacle shell hash on a sloping ledge on one of the pinnacles. We believe this is the first documented observation of juveniles of this species in the Gulf of Alaska. Water currents at the site are generally very strong, but are variable in both direction and strength depending on location. Numerous sections of derelict longline gear were observed on certain areas of the pinnacle, and damage to red tree corals was evident.

Six sites were surveyed with the *Delta* on Portlock Bank.. Two were relatively flat sites on the north end of the Bank, one lightly fished and one in an area fished for Pacific ocean perch. Two were sloping sites along the eastern slope edge and two sites were toward the middle of the Bank, one fished for flatfish, the other lightly fished. Little evidence of trawling was observed on the low relief grounds of the continental shelf where perhaps the level bottom did not induce door gouging and there was a lack of boulders to be turned over or dragged. The most common epifauna were crinoids, small non-burrowing sea anemones, glass sponges, stylasterid corals and brittlestars. Occasional large boulders were located in depressions were the only anomaly in the otherwise flat seafloor. These depressions may have afforded some protection to fishing gear, as the glass sponges and stylasterid corals attached to these boulders were larger than were typically observed. In contrast, there was evidence of boulders turned over or dragged by trawling in the areas of the upper slope. The uneven bottom perhaps induced gouging by the trawl doors. The substrate was mostly small boulders, cobble, and gravel. In summary, for this very limited sample of the outer Portlock Bank, there was very little high relief benthic habitat that would be at risk to further fishing. No large corals and very few large sponges were seen. The extent past fishing may have contributed to this condition is not known.

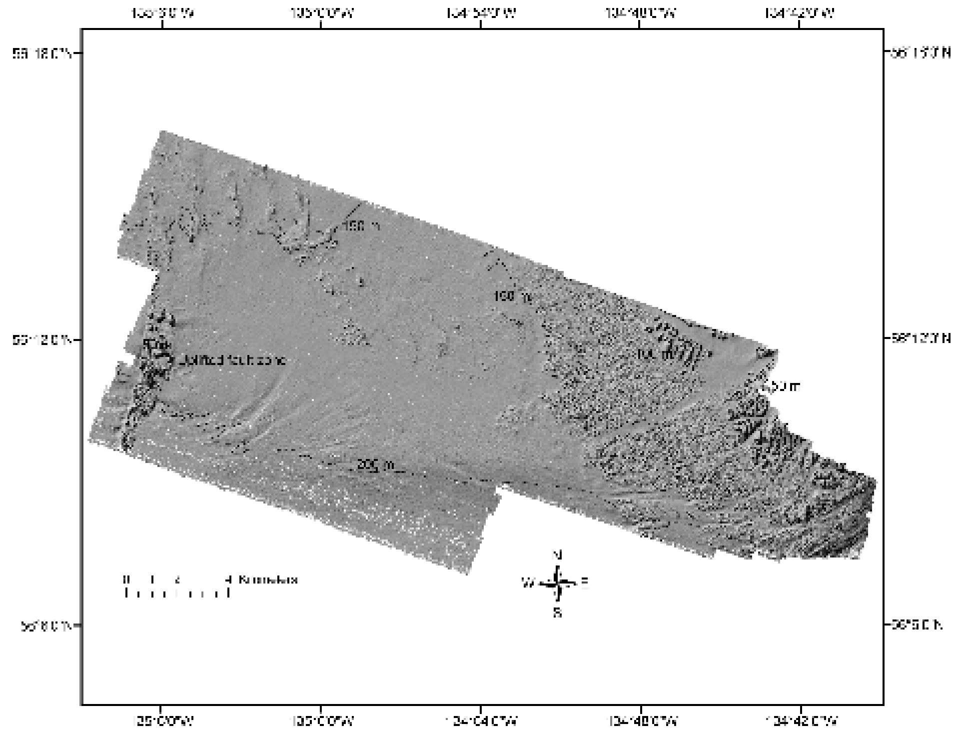

Figure 2. Bathymetric map of southeastern Alaska in the vicinity of Cape Omaney.

Effects of bottom trawling on soft-sediment epibenthic communities in the Gulf of Alaska.
Principal Investigator - Robert Stone (Alaska Fisheries Science Center - ABL)

In April 1987 the North Pacific Fishery Management Council closed two areas around Kodiak Island, Alaska to bottom trawling and scallop dredging (Type 1 Areas). These areas were designated as important rearing habitat and migratory corridors for juvenile and molting crabs. The closures are intended to assist rebuilding severely depressed Tanner and red king crab stocks. In addition to crab resources, the closed areas and areas immediately adjacent to them, have rich stocks of groundfish including flathead sole, butter sole, Pacific halibut, arrowtooth flounder, Pacific cod, walleye pollock, and several species of rockfish.

These closures provide a rare opportunity to study the effects of an active bottom trawl fishery on soft-bottom, low-relief marine habitat because bottom trawling occurs immediately adjacent to the closed areas. In 1998 and 1999 studies were initiated to determine the effects of bottom trawling on these soft-bottom habitats. The goal of these studies was to determine if bottom trawling in some of the more heavily trawled areas of the Gulf of Alaska, has chronically altered soft-bottom marine communities. Direct comparisons were possible between areas that were consistently trawled each year and areas where bottom trawling had been prohibited for 11 to 12 years. The proximity of the closed and open areas allowed for comparison of fine-scale infauna and epifauna diversity and abundance and microhabitat and community structure. Continuous video footage of the sea floor was collected with an occupied submersible at two sites that were bisected by the boundary demarcating open and closed areas.

The positions of 155,939 megafauna were determined along 89 km of seafloor. At both sites we detected general and site-specific differences in epifaunal abundance and species diversity between open and closed areas that indicate the communities in the open areas had been subjected to increased disturbance. Species richness was lower in open areas. Species dominance was greater in one open area, while the other site had significantly fewer epifauna in open areas. Both sites had decreased abundance of low-mobility taxa and prey taxa in the open areas. Site-specific responses were likely due to site differences in fishing intensity, sediment composition, and near bottom current patterns. Prey taxa were highly associated with biogenic and biotic structures; biogenic structures were significantly less abundant in open areas. In addition a relationship between epifaunal biomass and sea whip abundance was apparent (Figure 3). This relationship indicates that sea whip habitat may have increased productivity. Recent studies in the Bering Sea have shown a similar functional relationship for sea whip habitat. Evidence exists that bottom trawling has produced changes to the seafloor and associated fauna, affecting the availability of prey for economically important groundfish. These changes should serve as a "red flag" to managers since prey taxa are a critical component of essential fish habitat. Results from the epifauna component of this study were presented at Effects of Fishing Activities on Benthic Habitats symposium held in Tampa during November 2002.

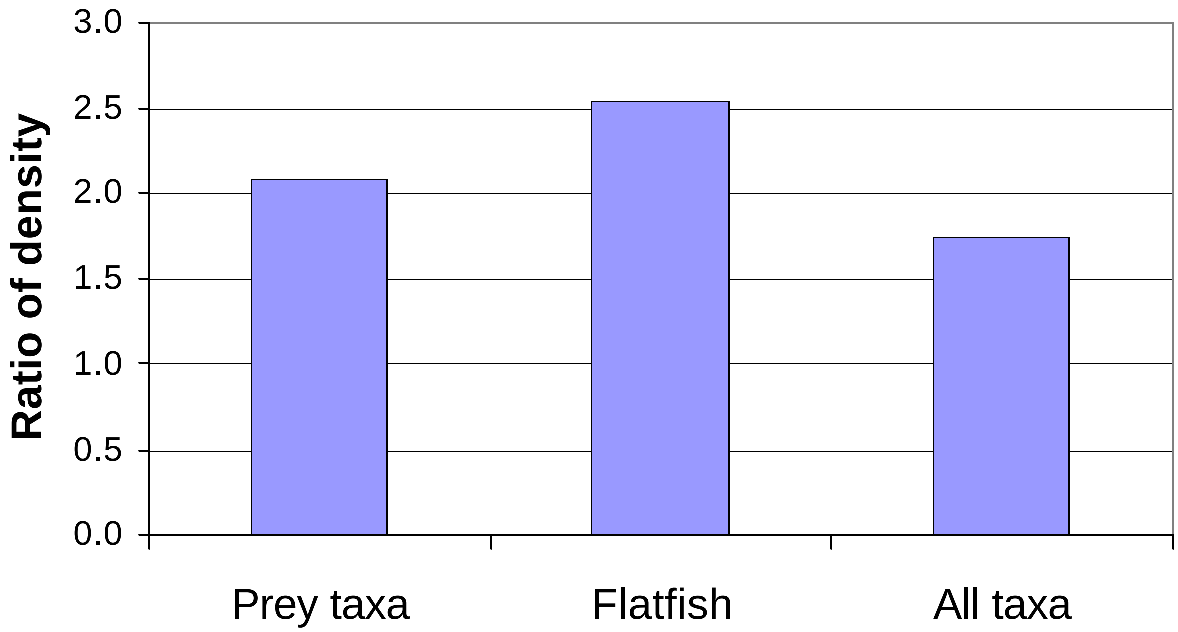

Figure 3. Ratio of density inside and outside of sea whip graoves at a site in the central Gulf of Alaska.

Effects of experimental bottom trawling on soft-sediment sea whip habitat in the Gulf of Alaska. Principal Investigator - Robert Stone (Alaska Fisheries Science Center - ABL)

In June 2001 a study was initiated to investigate the immediate effects of intensive bottom trawling on soft-bottom habitat and in particular an area colonized by sea whips. Sea whip biological characteristics and their resistance to two levels of trawling were studied. Sea whips are highly visible and changes in their abundance can be readily quantified. Within the study site, at least two species of sea whips (*Halipterus willemoesi* and *Protoptilum* sp.) are present with densities up to 10 individuals per m^2. Sea whip beds provide vertical relief to this otherwise homogeneous, low relief habitat. This habitat may be particularly vulnerable since sea whips can be removed, dislodged, or broken by bottom fishing gear. Furthermore, since sea whips are believed to be long-lived, recolonization rates may be very slow.

The study plan consisted of three phases. In *Phase 1*, baseline data was collected. The *Delta* submersible was used to collect *in situ* videographic documentation of the seafloor along 20 predetermined transects within the study area. Additionally, a bottom sampler was deployed from the submersible tender vessel to collect sediment samples (n=42) from the seafloor. During *Phase 2*, a commercial trawler outfitted with a Bering Sea combination 107/138 net, mud gear, and two NETS High Lift trawl doors made a single trawl pass in one corridor of the study area and repetitively trawled (six trawl passes) a second corridor. A third corridor was the control and was not trawled. *Phase 3* repeated the videographic and sediment sampling (n= 42) following the trawling phase. A scientist on board the *Delta* observed the seafloor and verbally identified biota and evidence of trawling including damaged or dislodged biota and marks on the seafloor from the various components of the bottom trawl (e.g., trawl door furrows, and ground gear striations) in synchrony with the external cameras. Analyses of sediment, chemical, and infauna abundance and diversity was completed in 2002. Video analysis of epifauna data was completed in Spring 2003 and data analyses are underway.

Living substrates in Alaska: distribution, abundance and species associations Principal Investigator - Patrick W. Malecha (Alaska Fisheries Science Center - ABL)

“Living substrates” have been identified as important marine habitat and are susceptible to impacts from fishing activities. In the Gulf of Alaska and Bering Sea, little is known about the distribution of deepwater living substrates such as, sponges (Phylum Porifera), sea anemones (Order Actiniaria), sea whips and sea pens (Order Pennatulacea), sea squirts (Class Ascidiacea), and bryozoans (Phylum Ectoprocta). In order to facilitate management practices that minimize fishery impacts to these living substrates, distributional maps were created based on National Marine Fisheries Service trawl survey data from 1975 through 2000. In general, the five groups of living substrates were observed along the continental shelf and upper slope in varying densities. Catch per unit effort (CPUE) of sponges was greatest along the Aleutian chain, while CPUE of sea squirts and ectoprocta was greatest in the Bering Sea. Large CPUEs of sea anemones, sea pens and sea whips were observed in both the Bering Sea and Gulf of Alaska. Broad-scale species associations between living substrates and commercial fish and crab were also investigated. Flatfish were most commonly associated with sea squirts and bryozoans; gadids with sea anemones, sea pens and sea whips; rockfish and Atka mackerel with sponges; and crab with sea anemones and sea squirts.

Sea whip (Order Pennatulacea) resiliency to simulated trawl disturbance Principal Investigator - Patrick W. Malecha (Alaska Fisheries Science Center - ABL)

Sea whip (*Halipteris willemoesi* and *Protoptilum* sp.) responses to simulated trawl disturbances were observed *in situ* and in laboratory aquaria. An aggregation of *H. willemoesi* was located at a depth of approximately 30 m in Auke Bay, Alaska. *H. willemoesi* were randomly assigned to three disturbance treatments and one control group and were observed *in situ*. Treatments included dislodgement, fracture of the axial rod, and tissue abrasion. *Protoptilum* sp. were collected with a shrimp trawl from a heavily colonized area of the seafloor in the Gulf of Alaska at a depth of 145 m. The ability of *Protoptilum* sp. to re-bury was observed in laboratory aquaria. Dislodged *H. willemoesi* showed a greater ability to re-bury and position themselves upright than did the smaller *Protoptilum* sp. After three months, *H. willemoesi* were not able to repair fractured axial rods but light tissue abrasion had little effect on survival. Dislodged and damaged *H. willemoesi* were much more vulnerable to predation by the nudibranch *Tritonia diomedea,* that appeared to illicit a strong scavenging/predatory response to sea whips in contact with the seafloor.

Growth and recruitment of an Alaskan shallow-water gorgonian. Principal Investigator - Robert Stone (Alaska Fisheries Science Center - ABL)

Little is known about the growth rates and lifespan of cold-water gorgonians. Some evidence exists that growth rates for these habitat-forming octocorals are low and that they are long-lived. Consequently, recovery rates from disturbance are likely low. A study was initiated in 1999 to examine the growth and recruitment of *Calcigorgia spiculifera*, the most common and abundant species of shallow-water gorgonian in Alaskan waters. This is the first study to directly measure coral growth *in situ* in the North Pacific. Two sites established in July 1999 were revisited during Cruise 03-09 aboard the NOAA Ship John N. Cobb. At these two sites, 36 of 38 colonies tagged in 1999 were relocated and video images recorded. These images will be digitized and growth determined from baseline images collected during the four previous years. A third study site was established in Kelp Bay, Baranof Island in 2000 where 30 colonies were tagged and images recorded. This site was unique in that it contained more than 1000 colonies, many of which were young (i.e., non-arborescent). At this site 19 of 30 colonies were relocated in August 2003 and video images were recorded. A manuscript describing the growth of this species, based on 5 years of growth data, is planned after the 2004 sampling season. Additionally, branch samples were collected from untagged colonies at all three locations in 2002 and 2003 and will be examined microscopically to determine the gonadal morphology, gametogenesis, and reproductive schedule for this species. This is the first research on the reproductive biology of any Alaskan coral species and should provide insights into the capability of cold-water gorgonians to recolonize areas set aside as mitigative measures, such as Marine Protected Areas.

Age Validation and Growth of Three Species of Pennatulaceans. Principal Investigator - Robert Stone (Alaska Fisheries Science Center - ABL)

Pennatulaceans (sea whips and sea pens) are locally abundant in Alaskan waters, susceptible to disturbance by bottom fishing activities, and are an important structural component to benthic ecosystems. Furthermore, research on one species (*Halipterus willemoesi*), indicates that they are long-lived and have low growth rates. This research was based on ring couplet (growth rings) counts but the periodicity of the couplets was not verified. To determine if the couplets are indeed annuli, 14 *Halipterus willemoesi* colonies were immersed in calcein solution and tethered to the seafloor where they were collected at -25 m depth. Preliminary results indicate that the calcein produced clear detectible marks on the axial rods. Examination of these specimens after one year will provide verification of the periodicity of ring couplets.

Axial rods from approximately 20 specimens each of the sea whips *Halipterus willemoesi* and *Protoptilum* sp. and the sea pen, *Ptilosarcus gurneyi*, are being examined for ring couplet counts. Examination of a wide size range for each species will provide estimates of growth rate, asymptotic size, and life span. One species (*Halipterus willemoesi*) will be collected from two populations subjected to different temperature regimes (Southeast Alaska and Bering Sea) and will allow us to examine the effects of temperature on growth rates. These data will allow us to estimate the growth rates of pennatulaceans throughout their geographical range and depth distribution.

Effects of long-term bottom trawling in the eastern Bering Sea (1996-2003) Principal Investigator - Robert A. McConnaughey (Alaska Fisheries Science Center - RACE Division)

Although chronic bottom trawling can reduce benthic biomass, it is generally unknown whether this represents a decrease in numbers of individuals or their mean body size. Body size directly affects the fitness of individuals, thereby influencing the structure and function of populations, communities and ecosystems. Although easily measured, it is rarely considered in the context of mobile fishing gear effects. Using data from the original study in 1996, we compared the mean sizes (kg) of 16 invertebrate taxa in heavily trawled (HT) and untrawled (UT) areas straddling the Crab and Halibut Protection Zone 1 (CHPZ1;area 512) closed area boundary in Bristol Bay (Figure 4). On average, fifteen of these taxa were smaller in the HT area and the overall HT-UT difference in body size was statistically significant. However, only the whelk *Neptunea* and the Actiniaria (sea anemones) were significantly smaller in the HT area after correcting for multiple tests. Mean size of red king crab was 23% *greater* in the HT area (P=0.17). Supplemental length-frequency data indicate that substantially fewer small red king crab, rather than more large individuals, occupy the HT area. For comparison with experimental results, we estimated natural size variability of benthic invertebrates by examining catches at standard NMFS trawl survey stations located within the CHPZ1 closed area. For each year from 1982 to 2001, the absolute value of the pairwise differences in mean size were calculated for all stations where a specific taxon was caught. These 10,018 within-year, within-taxon differences were then collected across years to generate an empirical distribution of differences in mean size based on natural variability among stations. Overall, these comparisons indicate natural variability of body size in the untrawled CHPZ1 is large relative to the observed HT-UT differences due to chronic bottom trawling. On average, spatial differences in body size exceeded the observed trawling effect in 91% of the comparisons involving sedentary taxa, 81% of those for motile taxa, and 22% of those for infauna.

When these results are considered in combination with biomass differences reported previously, it is possible to draw general conclusions about the overall status of the affected populations. In most cases, both biomass and mean body size were reduced as a result of heavy trawling suggesting a general population decline (Actiniaria, *Aplidium*, *Crangon*, *Cucumaria*, *Macoma*, *Neptunea*, *Oregonia gracilis*, pagurids, *Pagurus ochotensis*, *Serripes*, *Tellina*). In a few cases, greater overall biomass accompanied the observed body-size reduction, suggesting a proliferation of relatively small individuals in the HT area (*A. amurensis*, *Evasterias*, *Hyas*, *Mactromeris*). Mean size of red king crab (*P. camtschaticus*) was larger in the HT area. This was the only exception to the pattern of smaller individuals in the HT area. In this case, given lower biomass and substantially fewer small crab in the HT area relative to the UT area, the red king crab response to chronic bottom trawling appears to be fewer individuals of greater mean size.

Overall, the observed effects are generally consistent with theoretical expectations but were probably limited in magnitude by several factors. First, the CHPZ1 study area has a relatively high level of natural disturbance and there is general consensus that sandy areas with strong tidal flow are less sensitive to mobile gear effects. Also our findings probably reflect conditions associated with an intermediate stage of recovery, since active fishing in the HT area declined to a very low level prior to field sampling in 1996

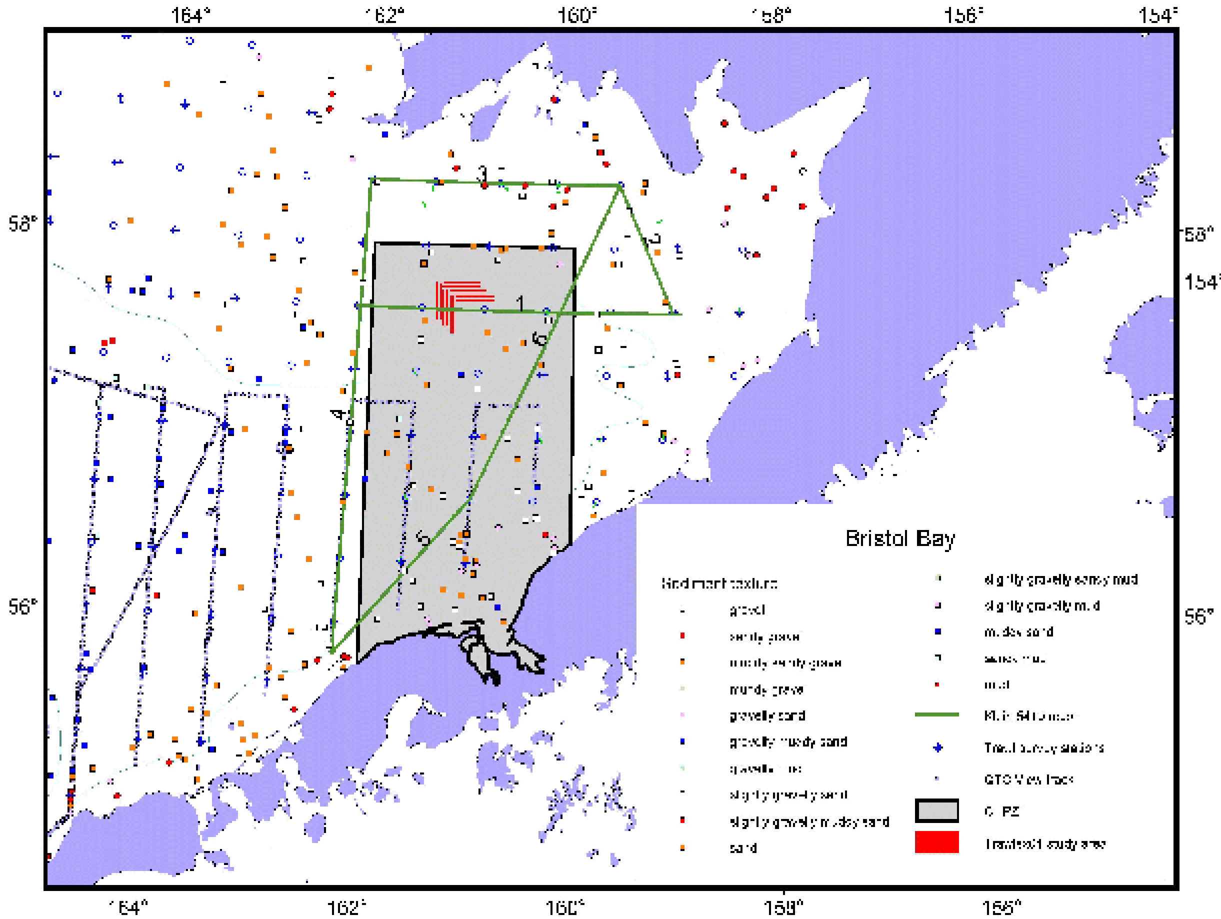

Figure 4. Bottom trawl study areas in Bristol Bay on the eastern Bering Sea shelf. Long-term (chronic) effects of trawling were investigated at heavily trawled and untrawled sites located along the northeast boundary of the CHPZ1 management area closed to trawling. Short-term effects and recovery are being studied in six pairs of research corridors within the CHPZ1. An exploratory survey of the Bristol Bay seafloor occurred along six reconnaissance tracklines.

(only five tows during 1993-1995). Moreover, trawl intensities for Alaskan waters are low relative to other shelf areas in the United States and Europe and the intensity level at the CHPZ1 study area is only moderate for the eastern Bering Sea shelf as a whole. Finally, our ability to comment on the ecological consequences of the observed effects is very limited at this time because so little is known about the life histories and ecological roles of the invertebrate taxa studied, not to mention the complex linkages among them and with federally managed groundfish.

Short-term trawling effects and recovery monitoring in the eastern Bering Sea (2001-present)
Principal Investigator - Robert A. McConnaughey (Alaska Fisheries Science Center - RACE Division)

Whereas earlier work focused on chronic effects of trawling, this ongoing multi-year study is a process-oriented investigation of short-term effects and recovery using a BACI experimental design. The study area is located within the CHPZ1 closed area, approximately 25-50 mi south and west of the chronic effects site (Figure 4). During a 35 day cruise in 2001, 6 pairs of predesignated 10-mi long research corridors were sampled before and after a trawling disturbance with commercial gear (NETS 91/140 Aleutian cod combination). Biological sampling consisted of 15 min research trawls for epifauna (n=72 total) and 0.1 m^2 van Veen grab samples for infauna (n=144 total at 2 per epifauna site). At each infauna sampling site, a second grab sample (n=144 total) was collected for characterizing carbon and nitrogen levels in surficial sediments, as well as grain size properties. The experimental and control corridors were also surveyed before and after trawling using a Klein 5410 side scan sonar system, to evaluate possible changes in sediment characteristics and bedforms. Taken together, the 2001 data quantify short-term changes in the experimental corridors due to trawling.

To investigate the recovery process, these same corridors were resampled in 2002 during a 21 day cruise aboard the same 155' trawler *F/V Ocean Explorer*. Sampling effort was equally divided between experimental and control corridors and was consistent with the level of effort in 2001. There was no commercial trawling event in 2002. A total of 36 epifauna trawls, 72 infauna grabs, 72 sediment grabs, and one side scan survey per corridor were performed. Combined, these data quantify recovery in the experimental corridors after one year using corrections for temporal variability measured in the control corridors.

The experimental design for this study will accommodate one additional series of epifauna sampling and multiple years of grab sampling after 2002, however the final recovery monitoring event has not yet been scheduled. At present, all 2001 samples are fully processed and ready for analysis while 2002 data processing is ongoing. Preliminary observations indicate a very diverse epifaunal community (approximately 90 distinct taxa) on very-fine olive-gray sand at 60 m depth. The seafloor appears to be brushed smooth in the 2001 side scan imagery, probably due to sizable storm waves and strong tidal currents that regularly disturb the area. Occasional video deployments on the trawls indicated somewhat greater complexity. Derelict crab pots are scattered throughout the study area and there is evidence of extensive feeding by walrus.

A systematic framework for assessing mobile fishing gear effects Principal Investigators Robert A. McConnaughey and Cynthia Yeung (Alaska Fisheries Science Center – RACE Division)

To some degree, our understanding of fishing gear impacts is constrained by the experimental methods being used. In general, the process of understanding mobile gear effects has three distinct phases. It begins with the identification of changes caused by gear contact, followed by controlled studies to determine the ecological effects and, ultimately, decision making based on some form of cost-benefit analysis. Nearly all of the research to date has targeted the specific changes in benthic invertebrate populations that occur when mobile fishing gear, particularly bottom trawls, contact the seabed. This worldwide focus on benthic invertebrates reflects their limited mobility and vulnerability to bottom-tending gear, and observations that structurally complex seabeds are an important element of healthy productive benthic systems. Effects are typically measured as changes in abundance or community structure. However, despite decades of intensive research, the overall impact of mobile fishing gear on marine ecosystems and, in particular, fish production is largely unknown. This reflects a need for substantially more research on the ecology of the affected invertebrates and their linkages to managed fish stocks, as well as more systematic studies of disturbance effects. Although certain gross generalities are possible, site-specific results are likely given variation in the composition of the benthos as well as the intensity, severity and frequency of both natural and anthropogenic disturbances. Because of the manner in which study areas are typically selected, any application of findings to other geographic areas is extremely tenuous. As such, there is a strong need to examine the issue more systematically so that research can move ahead from "case studies" of effects to the more interpretive (i.e. second) phase of investigation. To this end, we are working to identify areas with distinct invertebrate assemblages within which replicated *experiments* (not samples) could be placed and the aggregate findings applied to the entire area. The approaches being investigated are of two primary types and are detailed below: (1) mapping surficial sediments as a physical proxy for invertebrate assemblages, given benthic organisms have demonstrated strong affinities for particular substrates and (2) analyzing spatial patterns of the benthic invertebrates themselves. Whereas the former approach has potential advantages in terms of cost and relatively rapid spatial coverage, the latter has clear advantages related to the direct nature of the measurements since, after all, invertebrates are the *de facto* measure of gear effects.

Evaluating single beam echosounders for synoptic seabed classification Principal Investigators Robert A. McConnaughey and Stephen Syrjala (Alaska Fisheries Science Center – RACE Division)

Acoustic technology is particularly suited to synoptic substrate mapping since quantitative data are collected rapidly and in a cost-effective manner. The *QTC View* seabed classification system (Quester Tangent Corporation, Sidney, B.C.; QTC) is capable of background data acquisition during routine survey operations. Nearly 8 million digitized echo returns from the seafloor were simultaneously collected at two frequencies (38 and 120 kHz) along a 9,000 nm trackline in the eastern Bering Sea during a 1999 hydroacoustic fishery survey by the *Miller Freeman*. Collaborative analyses with the QTC are continuing in order to develop an optimum seabed classification scheme for the eastern Bering Sea shelf. Once this is accomplished, it will be possible to evaluate the system for benthic habitat studies using standardized measures of fish and invertebrate abundance from annual trawl surveys. Preliminary analyses indicate the system is able to detect and map seabed types with distinct acoustic properties. However, in order to have *habitat* mapping utility, this acoustic variability must correspond to environmental features that influence the distribution of demersal and benthic biota.

Acoustic diversity directly represents substrate diversity. Surface roughness, acoustic impedance, and volume homogeneity are characteristic of different seabed types; these factors influence echo returns from a vertical-incidence echo sounder. The standard QTC method uses a set of proprietary algorithms to extract features from individual echoes. Principal components analysis (PCA) reduces the full set of features to the three linear combinations that explain a large fraction of echo (seabed) variance. A three-factor cluster analysis then groups the echoes into distinct seabed types based on their acoustic diversity. Variation in continuous seabed properties is thus represented in discrete classes of seabed. The optimum scheme for any particular data set strikes a balance between high information content (i.e., many classes) and high confidence in the assigned class (e.g., if only one class).

Clustering methods typically require significant user input to decide which class to split next and when to stop splitting. To overcome this subjectivity and develop a fully-automated objective process, a new application of the Bayesian form of the Akaike Information Criterion (BIC, or "cost function") was developed to guide the clustering process. However, because of the computational intensity of the Bayesian method and the very large size of the two data sets, preliminary analyses were based on subsets of the data. Even so, over 200 CPU-hours were required to locate the global minimum of the BIC function which indicates the true number of seabed classes for each data set. Significantly better methods for finding minima in multi-dimensional spaces have been developed in the study of inverse problems, particularly simulated annealing (SA) and further developments based on SA. We have incorporated some of these techniques into our process in order to improve the program's ability to locate the global minimum (rather than a local minimum) of the BIC function. With this work nearing

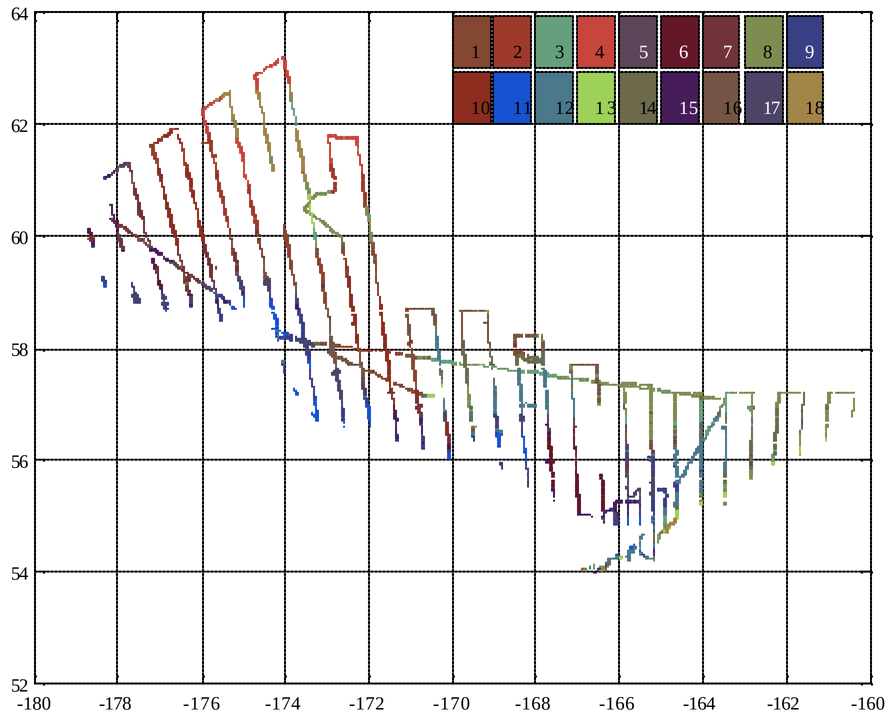

Figure 5. Seabed types on the eastern Bering Sea shelf, based on acoustic diversity measured with a 38 kHz echosounder and the *QTC View* seabed classification system. Similar types are represented with similar hues.

completion, the next step is to test for associations between the acoustically determined seabed classes and survey-based estimates of invertebrate (and groundfish) abundance (Figure 5).

Reconnaissance mapping with side scan sonar Principal Investigator Robert A. McConnaughey (Alaska Fisheries Science Center – RACE Division)

Upon completion of the 2002 bottom trawl study in the eastern Bering Sea, a reconnaissance of Bristol Bay seafloor habitats was undertaken using a high-resolution 500 kHz side scan sonar (Klein 5410). The reconnaissance effort was centered on an 800 mi^2 area of central Bristol Bay that has never been surveyed by NOAA hydrographers. A 150 m swath of bathymetric data and imagery were collected along survey lines totaling nearly 600 linear miles (Figure 4). The survey intentionally intersected six of the Bering Sea trawl study corridors currently being studied (above) in order to provide a spatial context for these results. In support of coordinated EFH characterization studies in the area, the reconnaissance survey also crossed 18 RACE Division trawl survey stations and followed 78 mi of seabed previously classified using a *QTC View* single beam acoustic system. Imagery was systematically groundtruthed using an underwater video camera and van Veen grab samples. Overall, a great diversity of complex sand-bedforms and other geological features were encountered in the survey area (Figure 6). The imagery is currently being processed and will be classified using supervised (geological) and unsupervised (statistical) methods in an effort to identify large homeogenous regions that would be the basis for more systematic study of mobile gear effects. Suitability for EFH characterizations will also be considered. Prior to deployments in Alaska in 2001 and 2002, a multi-institutional research team improved the commercial software interface for the sonar during laboratory testing and sea trials in Portsmouth Harbor, NH and Puget Sound, WA. In early 2003, the Klein system was co-purchased with the NOAA Office of Coast Survey (OCS) using accrued lease credits. In addition to joint fisheries habitat applications, reconnaissance data will also be supplied to OCS for nautical chart updates.

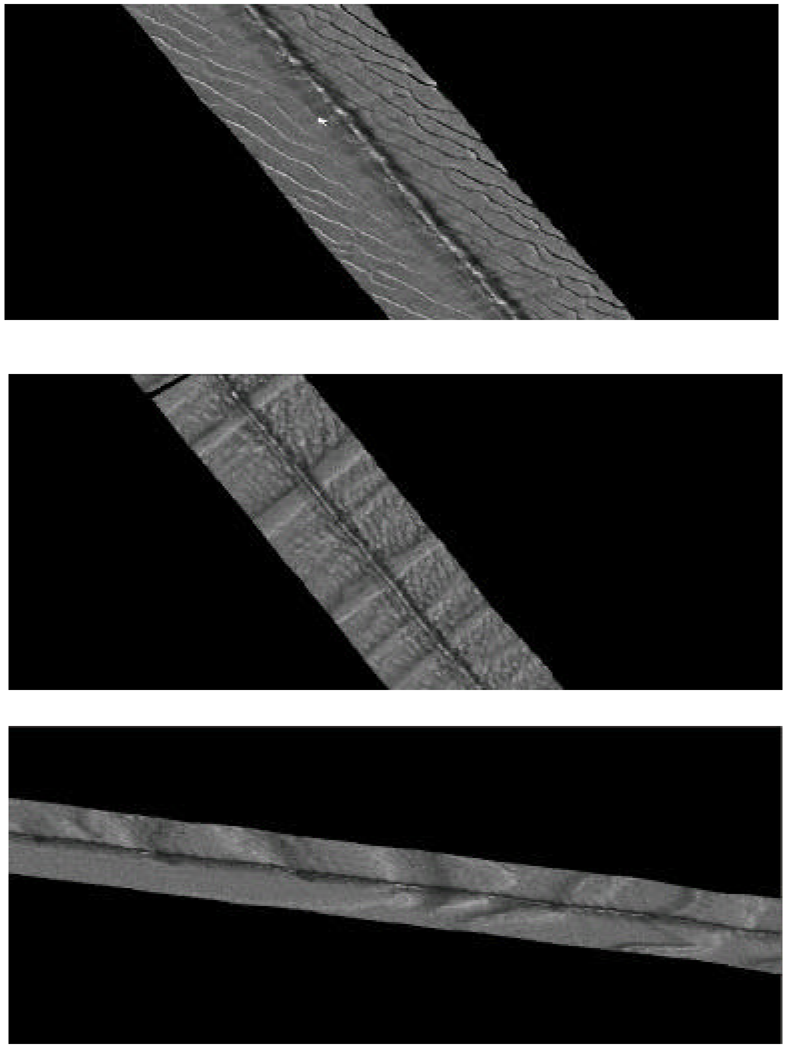

Figure 6. Representative side scan sonar images of sand bedforms acquired along Bristol Bay reconnaissance tracklines 2 and 3. Side scan technology is commonly used to map seabed features and characterize seafloor habitat complexity. A side scan towfish emits sound pulses and receives echos from the surrounding seabed while being dragged near the seafloor. Typical images contain information about the sediment type and general roughness of the seabed. For example, hard areas reflect more energy and are represented as dark areas on the image, while softer areas do not reflect energy as well and are represented with lighter shades. Digital multibeam systems, such as the Klein 5410, represent a significant improvement over the previous generation of digital "single beam" systems that require substantially slower towing speeds (2-3 knots vs 8 kts). Not only does this system produce extremely high-resolution backscatter images of the seafloor (pixels as small as 7.5 cm by 20 cm), co-registered swath bathymetry is also acquired simultaneously using interferometry. The swath bathymetry option enables direct measurements of small vertical features on the seabed, such as sand waves. Approximately 1 megabyte (MB) of data is collected each second from a 150 m swath.

Spatial and temporal patterns in Bering Sea invertebrate assemblages Principal Investigator Cynthia Yeung (Alaska Fisheries Science Center – RACE Division)

Invertebrate taxa exhibit highly specific geographical patterns reflecting their environmental requirements and ecological niches. These animals add important vertical complexity to the otherwise flat seabeds of the Bering Sea shelf and are also prey for commercially valuable species. In order to (1) characterize benthic habitats by invertebrate communities, and (2) detect temporal and spatial changes in community structure, invertebrate bycatch recorded during the annual RACE Division groundfish trawl surveys in the eastern Bering Sea (1982-2002) was examined. These analyses will provide a better understanding of the eastern Bering Sea benthos and may also provide a basis for designing an experimental system to systematically study mobile fishing gear impacts.

Some 400 invertebrate taxa have been recorded over all the surveys, with < 200 taxa occurring in an individual survey. Twenty-eight taxa were selected as the 'core' group for some analyses. They represent the dominant taxa in every survey either by frequency of occurrence at stations (presence) or by CPUE (kg/ha) (Table 1). Only 8 of the 28 taxa were not simultaneously dominant by presence and by CPUE. The scale worm *Eunoe nodosa*, although only marginally dominant, was added to the group for the lack of any annelid infauna, despite the importance of this group in characterizing marine soft sediment habitats and in marine benthic food webs.

Table 1. List of 'core' taxa, in decreasing rank of dominance.

Rank	Taxon	Rank	Taxon
1	Paguridae	15	*Boltenia* sp.
2	Gastropoda	16	*Argis* sp.
3	*Chionoecetes opilio*	17	*Erimacrus isenbeckii*
4	*Chionoecetes bairdi*	18	*Paralithodes platypus*
5	*Asterias amurensis*	19	*Crangon* sp.
6	*Gorgonocephalus eucnemis*	20	compound ascidean
7	*Hyas coarctatus*	21	*Ctenodiscus crispatus*
8	Actiniaria	22	Nudibranchia
9	Gastropod eggs	23	*Oregonia gracilis*
10	*Paralithodes camtschaticus*	24	*Telmessus cheiragonus*
11	*Hyas lyratus*	25	*Halocynthia* sp.
12	Porifera	26	Ophiuroidea
13	*Pandalus borealis*	27	*Gersemia* sp.
14	Echinacea	28	*Eunoe nodosa*

Stations in a survey were clustered by the dissimilarity of their taxa composition. All taxa that occurred in > 6% of the stations in a survey were included. CPUE (kg/ha) was 4^{th}-root transformed to balance the contributions of dominant and rare taxa, and Bray-Curtis dissimilarity was calculated on the station-by-taxa transformed CPUE matrix. A maximum of five clusters was kept. Above five clusters there was usually fragmentation into very small clusters with often just one member.

Consistently in almost every survey, two major groups of stations were found partitioned along either side of the 50 m isobath (Figure 7). Exceptions to this pattern are seen in 1982, 1988, and 1999, when the partition broke down and merged all stations essentially into one homogeneous group (1998 saw a contraction of the coastal cluster). The validity and significance of the possible 'anomalous' pattern is

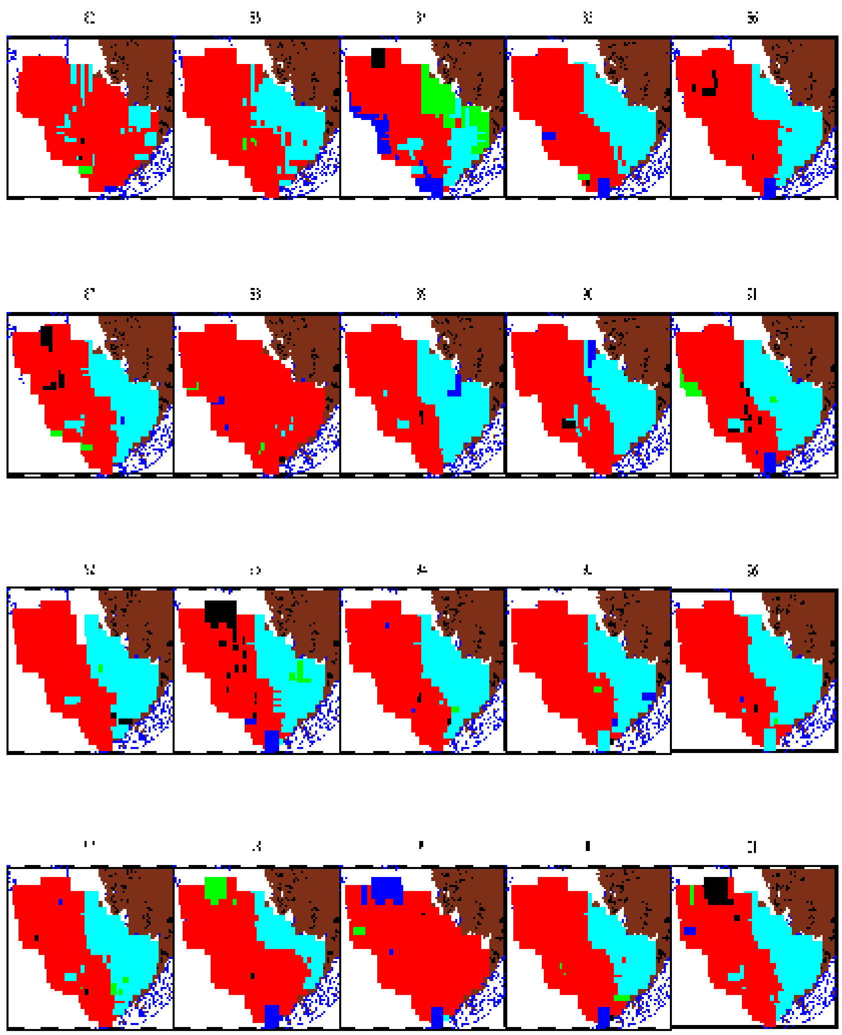

Figure 7. 1982-2001 eastern Bering Sea groundfish trawl survey stations clustered by taxa which occurred in >= 6% of the total number of stations. The maximum number of clusters kept was set at 5. Stations are color-coded by cluster membership for visual interpretation. Colors are assigned to facilitate the comparison of station groupings across surveys, not necessarily to imply the same colored stations across surveys have the same underlying "structure". The 2002 survey, not shown, resembles the 2001 pattern.

under investigation as is the utility of the two-group pattern for systematic studies of fishing gear effects. Trends and patterns in the biomass and spatial distribution of the invertebrate fauna are also being analyzed in relation to environmental variables and to the abundance and distribution of associated managed species.

Resolving taxonomic inconsistencies in Bering Sea invertebrate catch data Principal Investigator Keith Smith (Alaska Fisheries Science Center – RACE Division)

Benthic invertebrates are a key element of groundfish habitat and the primary measure of biological effects of mobile fishing gear. Since 1982, standard methods and gear have been used to sample benthic invertebrates in the eastern Bering Sea during an annual bottom trawl survey. However, due to differences in field practices and familiarity with taxa among years and vessels, specific organisms in the catch have historically been identified at various taxonomic levels. For example, the distinctive Alaskan hermit crab *Pagurus ochotensis* has been identified at the species level in some hauls and has been lumped with all other hermits in others. It is also frequently the case that common invertebrates have been identified to species while infrequent, less familiar ones were identified to higher taxonomic levels, without specific information about the extent of inclusion or exclusion of taxa in the larger groups. These situations are common for the hundreds of taxa routinely sampled and, if not handled carefully, will introduce significant biases into spatial and temporal analyses of survey catches. To overcome this problem and enable appropriate use of the survey data, a SQL-Plus application was developed that extracts user-selected invertebrate catch data for the eastern Bering Sea from the official AFSC survey database (RACEBASE) and groups them by the lowest common taxon (LCT). That is, using the example above, *P. ochotensis* records would be converted to and merged by haul with other Paguridae records when it could not be determined the larger group excluded the species-level records. This script is undergoing final testing and is currently configured to work with any combinations of years from 1982-2002 inclusive.

Identification of habitat areas of particular concern (HAPC) Principal Investigator - Lincoln Freese (Alaska Fisheries Science Center - ABL)

Habitat features such as deep water seamounts and shallower pinnacles are often highly productive because of their physical oceanography, and host a rich variety of marine fauna. Perusal of oceanographic charts for the Gulf of Alaska reveals that these features are relatively rare. In summer of 1999 and 2000 dives were conducted on isolated pinnacles from the research submersible *Delta*. The pinnacle surveyed in 1999 is located on the continental shelf approximately 40 nautical miles south of Kodiak, Alaska and rises from a depth of about 40 meters to within 16 meters of the surface. The surrounding habitat is relatively featureless sand. The pinnacle hosted large aggregations of dusky rockfish, kelp greenling, and lingcod, similar to aggregations noted on a pinnacle located in the vicinity of the Sitka Pinnacles Marine Reserve. The pinnacle provides substrate for dense aggregations of macrophytic kelps beginning at the 20 meter isobath and continuing to the top of the pinnacle. These kelp beds may provide essential rearing habitat, as evidenced by the numerous juvenile fish (presumably rockfish) observed swimming among the kelp fronds. Although no evidence of fishing gear impacts were noted from the submersible, it is located SW of Kodiak Island adjacent to areas that are extensively trawled.

The pinnacles surveyed in 2000 were located in southeast Alaska west of Cape Omaney. The survey was designed to determine if the site met the criteria for designation as HAPC. The extent of the site was successfully charted from the *R/V Medeia*. The site measures approximately 400 x 600 m and contain a series of pinnacles. Maximum vertical relief is approximately 55 m, and water depths range between 201 and 256 m. Seven dives at the site were completed to document habitat and associated biota. An additional 5 dives were performed to collect specimens of red tree coral, sponges, and predatory starfish. The substrate is primarily bedrock and large boulders, most likely composed of mudstone, and provides abundant cover in the form of caves and interstices of various sizes. The epifaunal community is rich and diverse, much more so than the surrounding low-relief habitat. The largest epifauna were gorgonian red tree coral colonies and several species of sponges. These organisms are not evenly distributed at the study site. Review of the video and audio data may provide insights into habitat features or oceanographic processes affecting distributions of coral and sponges. Numerous species of fish, including several species of rockfish, are present in relatively large numbers. Redbanded rockfish and shortraker/rougheye rockfish were often associated with gorgonian coral colonies and at least one species of sponge. Also of interest was the presence of a pod of several hundred juvenile golden king crab on acorn barnacle shell hash on a sloping ledge on one of the pinnacles. We believe this is the first documented observation of juveniles of this species in the Gulf of Alaska. Water currents at the site are generally very strong, but are variable in both direction and strength depending on location. Numerous sections of derelict longline gear were observed on certain areas of the pinnacle, and damage to red tree corals was evident.

In 2001 a series of surveys were completed from the submersible *Delta* in areas of the GOA offshore from Seward southeastward to Yakutat, Alaska. Purpose of the surveys was to determine presence and relative abundance of red tree coral. Choice of survey sites was based on catch of red tree coral brought up in NMFS trawl survey tows. A number of those tows resulted in high catch rates (up to 5800 kg per tow) of coral. In 2001 a total of 18 submersible dives were made at some of these locations. Preliminary analysis of the data reveals that most of these sites were bereft of red tree coral. Three of the sites had small numbers of coral colonies attached to scattered boulders or rock substrates. Most sites were of low-relief with relatively fine substrate and provide relatively low levels of habitat complexity. One such site contained widely scattered boulders, some with attached sponges (*Aphrocallistes* sp.). Numerous juvenile (5-10 cm) rockfish were observed closely associated with the sponges. No juvenile rockfish were found on boulders devoid of sponges. Two dives were made at sites selected based on bathymetric features rather than past trawl survey results. The sites were located along the northwestern and southwestern edges of the Fairweather Grounds, and consisted of high-relief, rocky substrates. One site contained extremely high densities of very large red tree coral. The second site, although similar to the first, was devoid of red tree coral. Observations made during the 2001 survey indicate that red tree coral colonies in the areas studied exhibit patchy distribution and that abundance and distribution estimates of the species based on trawl survey data may be imprecise. In 2002 and 2003 focus was on collection of data from the submersible videos.

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